

# (12) UK Patent Application (19) GB (11) 2 332 125 (13) A

(43) Date of A Publication 09.06.1999

(21) Application No 9803829.2  
(22) Date of Filing 25.02.1998  
(30) Priority Data  
(31) 08986810 (32) 08.12.1997 (33) US

(51) INT CL<sup>6</sup>  
H04Q 7/38  
(52) UK CL (Edition Q )  
H4L LDSM L1H10  
(56) Documents Cited  
GB 2314733 A GB 2269962 A

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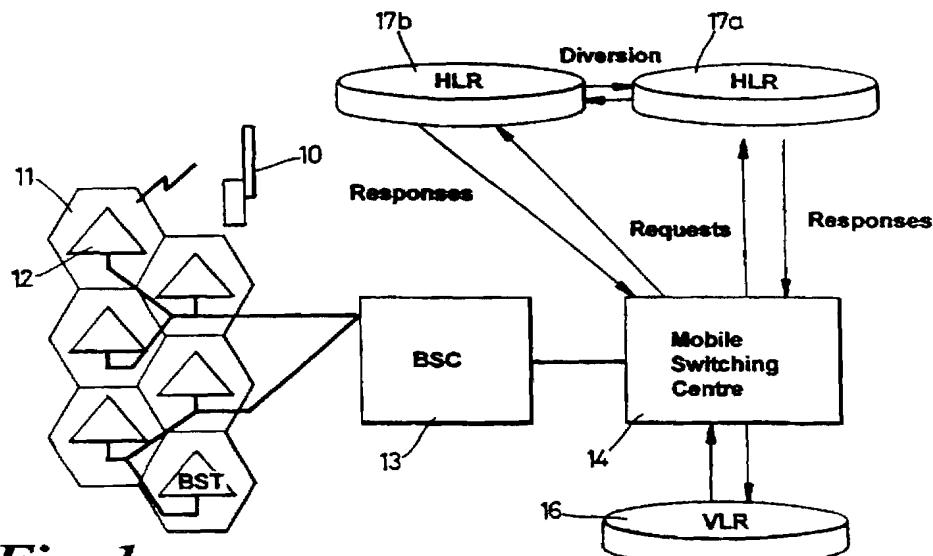
(58) Field of Search  
UK CL (Edition P ) H4L LDSM  
INT CL<sup>6</sup> H04Q 7/38  
On-Line - WPI

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(54) Abstract Title  
**Home location register with expandable storage capacity**

(57) A mobile communications system incorporates a plurality of home location registers 17a, 17b on which subscriber data is stored such that each subscriber is allocated to a selected one of the registers for voice and/or data calls. Request messages for subscriber data can be routed to any home location register which responds to that request when the data for the respective subscriber is stored on that home location register. If the data for the respective subscriber is not stored on that home location register, the message is provided with an indicator component and is rerouted to another home location register for a further processing attempt. The number of times a message is rerouted is limited to prevent perpetual circulation of messages relating to unknown subscribers.



**Fig. 1**

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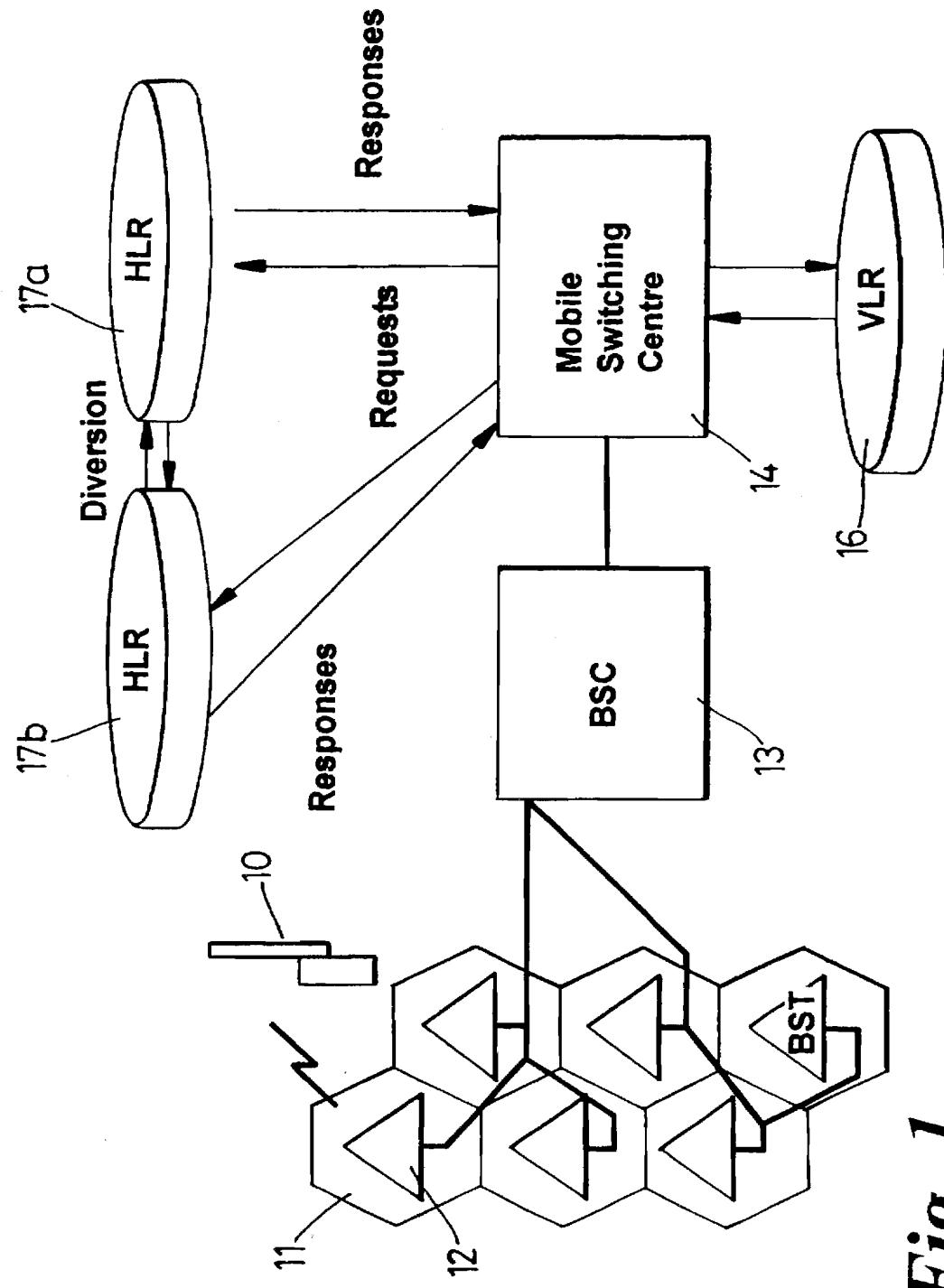


Fig. 1

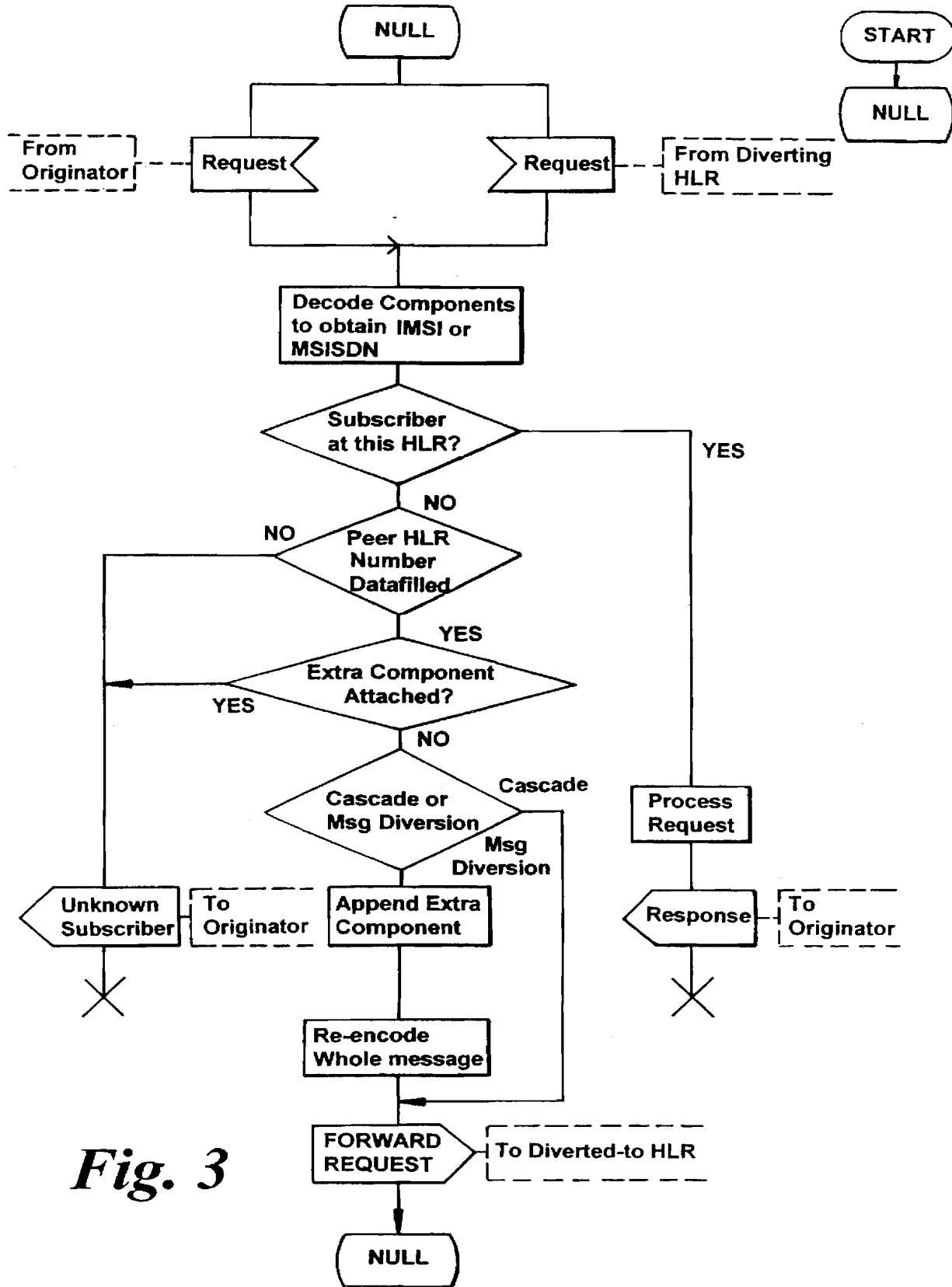
**Table 1** Diverting and Diverted-to HLR Processing Logic

<b>Subscriber Status</b>		<b>Messages from Network</b>	<b>Re-routed Messages</b>
<b>Activated (A)</b>		Process request	Process request
<b>New / Naughty (N)</b>	<b>Unrestricted request</b>	Process request	Process request
	<b>Restricted request</b>	Return Unknown Subscriber error	Return Unknown Subscriber error
<b>Replacement (R)</b>	<b>Swapover occurred</b>	Process request	Process request
	<b>No swapover</b>	Re-route to Diverted-to HLR	Return Unknown Subscriber error
<b>Deactivated<sup>a</sup> (D)</b>		Re-route to Diverted-to HLR	Return Unknown Subscriber error
<b>Subscriber not in the database</b>		Re-route to Diverted-to HLR	Return Unknown Subscriber error

a. Deactive subscribers have their requests re-routed because the operator may have put them in this state prior to removing them from the database.

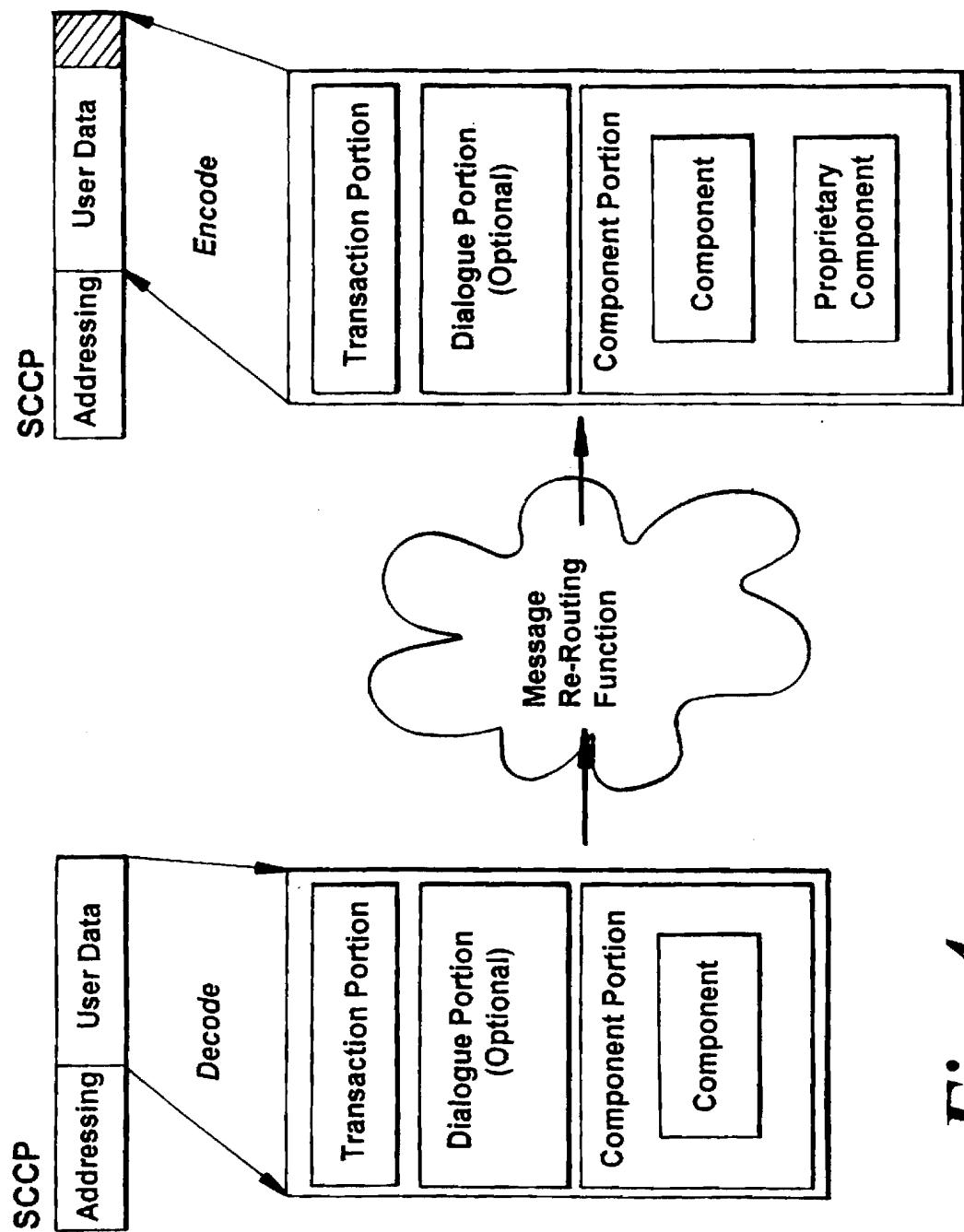
***Fig. 2***

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**Fig. 3**

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**Fig. 4**

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**CELLULAR COMMUNICATIONS SYSTEM**

This invention relates to cellular communications systems or networks, and in particular to the storage and retrieval of subscriber information in such systems.

**5 BACKGROUND OF THE INVENTION**

A number of cellular communications systems are currently being installed to provide communications facilities to mobile terminals. In such systems, mobile terminals are served by base stations via a radio or air link, each base station defining a system cell. In order that a subscriber may be identified as an authorised system user and located so as to receive calls or other system services, the system is provided with a central database containing subscriber information which can be accessed as required. In the standardised European system commonly referred to as the GSM system, this central store is known as the home location register (HLR). The number of subscribers to mobile communications systems is rapidly increasing, and service providers are becoming concerned that their systems should have sufficient capacity to accommodate these subscribers. A particular problem is the need to store information relating to subscribers on the system home location register, as it will be appreciated that the installed storage capacity of a home location register is finite. Although

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systems have been designed to allow for future expansion, the unexpected growth in the number of mobile subscribers will soon exceed the storage limits of the present home location registers. One solution to this problem is the installation of a larger home location  
5 register to replace existing equipment. However, this is generally undesirable both on the grounds of cost and the possible system disruption that can occur during installation. An alternative solution is the provision of second home location register to which new subscribers are allocated when the existing register becomes full thus  
10 effectively doubling the storage capacity. It has been found however that this introduces a routing problem as each request then requires the inclusion of a code indicating the identity of the particular home location register to which the subscriber has been allocated. This requires modification of the network routing tables to accommodate  
15 this additional information and can lead to a complex routing which is difficult to manage.

Our co-pending application serial No 08/884309 discloses a mobile network arrangement incorporating two or more home location  
20 registers. In this arrangement, a primary home location register (HLR) is provided with one or more cascaded home location registers to which some of the subscribers are allocated. This permits sharing of the workload in processing the subscriber information requests that are involved in the setting up of calls. Routing of requests to the correct  
25 HLR is simplified by routing all such requests to the original or master HLR and forwarding only those requests for which data is stored on one of the back-up or cascaded HLRs. This avoids the need for changes in the existing system routing plan when new subscribers are added or when a subscriber's details are transferred from one HLR to  
30 another.

The arrangement and method described in serial No 08/884309 addressed the problem of introducing a second or auxiliary home location register to an existing system to meet subscriber growth without the need for changes to existing network routing tables.

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In a mobile telephone network, such as a GSM network, the routing of messages to a home location register is normally based on the subscriber number, the IMSI or the MSISDN. The IMSI, which is provided on the subscriber's SIM card, is an internal network identification of the subscriber and the MSISDN is the subscriber's dialable phone number. Ideally, there will be a co-ordination between the allocation of a subscriber's MSISDN and IMSI.

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In a network having more than one home location register, the subscribers will generally be partitioned logically between the registers. In order for a subscriber to gain access to the network, he must first obtain a SIM card, usually from a mobile phone retailer. However, the distribution of SIM cards to retailers and their subsequent allocation to subscribers cannot be strictly controlled, and the direct co-ordination 15 between IMSIs and MSISDNs may be lost.

20

Ideally, network translations should route IMSI and MSIDN based messages to the same HLR. However, because the co-ordination of these two numbers cannot be guaranteed owing to the aforementioned difficulty of controlling the retail outlets issuing SIM cards to customers, it is possible for an IMSI based subscriber message to be routed to one HLR and a MSIDN message for the same subscriber to be rerouted from that HLR to another HLR. Further, where a subscriber's details 25 are not stored on any system HLR, there is a risk that messages relating to that subscriber will be perpetually forwarded between HLRs.

**SUMMARY OF THE INVENTION**

It is an object of the present invention to provide an improved system and method for increasing the subscriber data storage capacity of a cellular communications network.

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It is another object of the invention to provide an improved mobile telephone network incorporating two or more home location registers.

10 It is a further object of the invention to provide an improved method of messaging between home location registers in a mobile telephone system.

According to one aspect of the invention there is provided a method of routing subscriber information request messages in a cellular 15 communications network incorporating a plurality of home location registers on which registers subscriber data is stored such that each subscriber is allocated to a selected one of said registers for voice and/or data calls, the method including routing a request message to a said home location register, processing the request message at that 20 said home location register when the corresponding subscriber details are stored on that home location register, and diverting the message to one or more other home location register whereby to attempt processing of the request message at one of said other home location registers, and wherein the number of diversions to which a said 25 request message is subjected is limited to a predetermined number.

According to another aspect of the invention there is provided a 30 method of routing subscriber information request messages in a cellular communications network incorporating a plurality of home location registers on which registers subscriber data is stored such that each subscriber is allocated to a selected one of said registers for

voice and/or data calls, the method including routing a said request to one said home location register, responding from that home location register to a said request message when the subscriber data relating to that request is stored on that home location register, rerouting a said  
5 request message from that home location register to a said further home location register when the subscriber data is not found on the selected one home location register, and providing an indication to said further home location register that the request message has been rerouted whereby to limit the number of diversions to which a said  
10 request message is subjected to a predetermined number.

According to another aspect of the invention there is provided a mobile communications system incorporating a plurality of home location registers on which subscriber data is stored such that each subscriber  
15 is allocated to a selected one of said registers for voice and/or data calls, means for routing request messages for subscriber data to selected one home location register, means associated with the selected one location register for responding to a said request when the data for the respective subscriber is stored on that home location  
20 register, and message rerouting means associated with each said home location register for rerouting a said subscriber data request message to another said home location register when the data for the respective subscriber is not stored on that home location register and for providing an indication to said further home location register that the  
25 request message has been rerouted whereby to limit the number of diversions to which a said request message is subjected to a predetermined number.

According to a further aspect of the invention there is provided a home  
30 location register arrangement for a mobile communications system, the arrangement comprising a plurality of home location registers on which

subscriber data relating to system subscribers is stored and to which, in use, request messages for subscriber data are routed, each subscriber being allocated to a selected one of said registers for voice and/or data calls, the arrangement incorporating means associated

- 5 with each said home location register for responding to a said request message when the data for the respective subscriber is stored on that home location register, and message re-routing means associated with each said home location register for forwarding a said subscriber data request message to another said further home location register when
- 10 the data for the respective subscriber is not stored on the first home location register and for providing an indication to said further home location register that the request message has been rerouted whereby to limit the number of diversions to which a said request message is subjected to a predetermined number.

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In a further aspect, the invention provides a home location register arrangement for a mobile communications system, the arrangement comprising a pair of home location registers on which subscriber data relating to system subscribers is stored and to which, in use, request

- 20 messages for subscriber data are routed, each subscriber being allocated to a selected one of said registers for voice and/or data calls, wherein each said home location register incorporates message diversion means for forwarding messages for which the corresponding subscriber cannot be found on that home location register to the other
- 25 home location register, and wherein each said home location register incorporates means for identifying a diverted message and for inhibiting further diversion of that message.

- 30 The technique overcomes the network routing problem by ensuring that subscriber requests routed to an incorrect HLR are rerouted to the correct HLR via a subscriber specific rerouting function.

Further, new home location registers can be introduced to an existing system on a retrofit basis to accommodate subscriber growth without the need to alter the system request routing plan. New subscribers  
5 can be allocated to a newly installed home location register, or existing subscribers can be transferred from one register to another to balance the system workload.

Selection of a home location register to which a message should  
10 initially be routed may be performed on a random or on a rota basis. Similarly, subscribers can be allocated to a home location register e.g. on a random basis, or on a geographical basis determined from their home location. In a further embodiment, the allocation of subscribers to home location registers may be determined on the basis of user  
15 profiles so as to balance the system work load. Subscribers may also be transferred from one home location to another to facilitate work load balancing.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

20 Embodiments of the invention will now be described with reference to the accompanying drawings in which:-

Figure 1 is a schematic diagram of a mobile communications system incorporating a plurality of home location registers;

25 Figure 2 illustrates a message diversion protocol employed in the system of figure 1;

Figure 3 is a flow chart of the message diversion process; and

Figure 4 illustrates a message rerouting function for use in the system of figure 1;

#### **DESCRIPTION OF PREFERRED EMBODIMENT**

5 Referring to figure 1, there is depicted in highly schematic form part of a mobile cellular communications network or system. The service area of the system is subdivided into a plurality of contiguous cells 11 in each of which mobiles 10 are serviced via a respective base station 12. Operation of a group of base stations 12 is controlled via a base station controller 13 and, in turn, a number of base station controllers are serviced by a mobile switching centre (MSC) 14 which may provide an interface to the public telecommunications network (not shown). Within this arrangement, the mobile switching centre 14 may service, via the base station controllers 13 and the base stations 12, typically over one  
10 hundred individual cells 11. Information relating to the mobiles 10 that are currently located within the service area of the mobile switching centre 14 is stored in a visitors location register (VLR) or database 16 associated with the mobile switching centre. For clarity, figure 1 depicts only one MSC and its associated VLR, but it will be appreciated  
15 that the system will incorporate a number of MSCs each servicing its respective zone.  
20

In the GSM, DCS-1800 and PCS-1900 schemes, a subscriber is identified using two unique identities. The International Mobile  
25 Subscriber Identity (IMSI) is used for non-call related requests to the HLR typically from the VLR, for example location updating. The IMSI is held in the subscriber identity module (SIM) of the mobile station, typically on a 'SIM card' and is not visible nor accessible to the subscriber. The Mobile Subscriber ISDN (MSISDN) is used for call  
30 related requests to the HLR typically from the MSC, for example "Send Routing Information". The MSISDN is associated with a teleservice in

the HLR and is visible to caller and subscriber as the 'dialled number'. An MSC originated message will only carry an MSISDN and will not carry an IMSI. Similarly, a VLR originated message will only carry an IMSI and not an MSISDN. Thus, requests to a HLR from the network  
5 will be based on either the IMSI or MSISDN. However the important point to note is that it is relatively easy for an operator to change a subscriber's IMSI but very disruptive to change the MSISDN. A second important point is that from the network perspective there is no intrinsic relationship between an IMSI and a MSISDN other than routing derived  
10 from them should result in a message arriving at the same HLR for the same subscriber to which they refer .

The system of figure 1 incorporates two or more master databases or home location registers 17a, 17b, each of which stores subscriber information and is arranged to respond to request messages from MSCs or from VLRs for subscriber information. For clarity, figure 1 shows only the MSC request and response communication paths, but it will be understood that similar communication paths will be provided between the visitors location register and the home location registers  
15 20 for carrying requests and responses therebetween.

In the arrangement of figure 1, each system subscriber is allocated to one of the home location registers at least in respect of voice calls. Ideally the subscriber should also be allocated to that same home  
25 location register in respect of data calls although, as discussed above, this will not always be possible.

When a mobile terminal enters the service area of the MSC 14, it registers with that MSC/VLR so that the terminal can then originate or  
30 terminate calls. As part of the registration procedure, it is necessary for information or data relating to that mobile to be retrieved by the

MSC from the appropriate home location register on which that subscriber's details are stored, and these details are then stored in the visitors location register until such time as the mobile terminal leaves the service area of the MSC. In this way, the system is constantly 5 updated with the current location of each mobile terminal so that calls to that mobile can be routed to the correct mobile switching centre for termination at the mobile.

Referring now to figure 2, this illustrates a message diversion protocol 10 for a pair of home location registers for use in the system of figure 1. Reference is also made to figure 3 which is a flow chart of the request message handling process for the system. The home location register receiving a request message is referred to as the diverting HLR (whether or not message diversion is in fact required) and the home 15 location register receiving a diverted message from the diverting HLR is referred to as the diverted-to HLR. Note that each home location register can function both as a diverting HLR and as a diverted-to HLR.

In this system, the mobile switching centre or visitors location register 20 sending the request message for subscriber details does not know, nor has any need to know, which of the home location registers contains that subscriber's details. Preferably the request messages sent to a home location register and the responses to those messages are encoded to prevent "eavesdropping" which could the subscriber's IMSI 25 or MSISDN and thus facilitate unauthorised cloning of a subscriber terminal.

Each request message incorporates an addressing portion and a user 30 data portion, the former being referred to as a signalling connection control part (SCCP) and the latter a transaction capability application part (TCAP). The SCCP message incorporates the called party

address (CdPA) and the calling party address (CgPA). The TCAP message comprises a transaction portion incorporating the subscriber information request, an optional dialogue portion and a component portion.

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A request message can be sent to any one of the home location registers, i.e. that home location register can be the diverting HLR for that particular message. Selection of the home location register to which the request message is sent can be determined on a rota basis, 10 on a random basis, or the home location register with the shortest message queue can be selected. In a further embodiment, those subscribers with the highest volume of call traffic and/or a high degree of mobility can be identified and appropriately allocated to selected home location registers so as to spread or balance the system work 15 load. This ensures that no one HLR is so unduly overloaded that it cannot readily identify and divert those requests for which subscriber information resides on another HLR.

At the diverting HLR, the received request message is processed up to 20 the point where the subscriber's identity (IMSI or MSISDN) is identified and verified. This is done by decoding the message to recover the IMSI or MSISDN. If the subscriber's details are found, and it is confirmed that the subscriber is entitled to have access to the network, and if the relevant subscriber details then are found on the diverting 25 HLR, the request is processed and the appropriate details are returned to the originator of the request message. If an improper or unauthorised subscriber identity is determined, an error message is returned to the sender so that access to the network can be denied. Further processing of that request is then terminated.

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If however the subscriber's identity is confirmed but the corresponding details are not found on that home location register, an indicator component is added to the message which is then re-encoded and rerouted to the diverted-to HLR. At the diverted-to HLR, the message

5      is again decoded to recover the IMSI or MSISDN and a search is made for the subscriber details. If the relevant subscriber details are found on the diverted-to HLR, the request is processed and the appropriate details are returned to the originator of the request message. If the subscriber details cannot be found and the added

10     indicator component is determined to be present in the decoded message, an error or unknown subscriber message is returned to the message originator. The use of this indicator component of a message to identify a diverted message prevents a message relating to an unknown subscriber from being bounced back and forth

15     between the home location registers.

The use of the indicator component technique described above can be extended to a system having more than two home location registers. In such a system, the indicator component is used either to

20     identify the number of times a message has been diverted or to list the identities of those home location registers that have previously diverted the message. When the number of diversions is one less than the number of home location registers and the subscriber details cannot be found, an unknown subscriber error message is generated

25     and no further diversions are permitted.

The message rerouting function employed in the system of figure 1 is illustrated in figure 4. When a diverting HLR decides to reroute a message, it calls up the message rerouting function. This function

30     reconstructs the original TCAP message by decoding the user data portion, and appends another component to its component portion. It

is the presence of this further component in the message that will provide an indication to the diverted-to HLR that the message has been diverted from the diverting HLR. The diverted-to HLR number is placed in the called party address (CdPA) in the SCCP portion of the

5 message. The calling party address (CgPA) of the message is preserved so that any subsequent response from a diverted-to HLR can be returned to the original requester.

If the diverted request message reaches the diverted-to HLR and

10 there is a problem in processing the message, e.g. the subscriber is not registered with the diverted-to HLR, an error message indicative of the problem is returned to the original requester whose calling party address has been preserved in the message.

15 The above description of the construction and use of systems incorporating a plurality of home location registers makes particular reference to use in a land based mobile communications system. However, it will be understood that use of the technique is in no way limited to land based systems and that it is equally applicable to

20 mobile communication systems incorporating geostationary or non-geostationary satellite nodes.

**We Claim:-**

1. A method of routing subscriber information request messages in a cellular communications network incorporating a plurality of home location registers on which registers subscriber data is stored such that each subscriber is allocated to a selected one of said registers,  
5 the method including routing a request message to a said home location register, processing the request message at that said home location register when the corresponding subscriber details are stored on that home location register, and diverting the message to one or more other home location register whereby to attempt processing of  
10 the request message at one of said other home location registers, and wherein the number of diversions to which a said request message is subjected is limited to a predetermined number.
  
2. A method of routing subscriber information request messages  
15 in a cellular communications network incorporating a plurality of home location registers on which registers subscriber data is stored such that each subscriber is allocated to a selected one of said registers for voice and/or data calls, the method including routing a said request to one said home location register, responding from that home location  
20 register to a said request message when the subscriber data relating to that request is stored on that home location register, rerouting a said request message from that home location register to a said further home location register when the subscriber data is not found on the selected one home location register, and providing an  
25 indication to said further home location register that the request message has been rerouted whereby to limit the number of diversions to which a said request message is subjected to a predetermined number.

3. A method as claimed in claim 2, wherein each said request message comprises an addressing portion indicative of the message origin and destination and a data portion.
- 5 4. A method as claimed in claim 3, wherein the data portion of each said message comprises a component portion and a transaction portion, the transaction portion containing the request for subscriber information.
- 10 5. A method as claimed in claim 4, wherein said indication that a message has been rerouted by a home location register comprises an indicator component inserted in the component portion of the message by that home location register.
- 15 6. A method as claimed in claim 4, wherein the data portion of each said message incorporates a dialogue portion.
7. A mobile communications system incorporating a plurality of home location registers on which subscriber data is stored such that each subscriber is allocated to a selected one of said registers for voice and/or data calls, means for routing request messages for subscriber data to selected one home location register, means associated with the selected one location register for responding to a said request when the data for the respective subscriber is stored on that home location register, and message rerouting means associated with each said home location register for rerouting a said subscriber data request message to another said home location register when the data for the respective subscriber is not stored on that home location register and for providing an indication to said further home location register that the request message has been rerouted whereby to limit

the number of diversions to which a said request message is subjected to a predetermined number.

8. A home location register arrangement for a mobile  
5 communications system, the arrangement comprising a pair of home  
location registers on which subscriber data relating to system  
subscribers is stored and to which, in use, request messages for  
subscriber data are routed, each subscriber being allocated to a  
selected one of said registers for voice and/or data calls, wherein each  
10 said home location register incorporates message diversion means for  
forwarding messages for which the corresponding subscriber cannot  
be found on that home location register to the other home location  
register, and wherein each said home location register incorporates  
means for identifying a diverted message and for inhibiting further  
15 diversion of that message.

9. A home location register arrangement for a mobile  
communications system, the arrangement comprising a plurality of  
home location registers on which subscriber data relating to system  
20 subscribers is stored and to which, in use, request messages for  
subscriber data are routed, each subscriber being allocated to a  
selected one of said registers for voice and/or data calls, the  
arrangement incorporating means associated with each said home  
location register for responding to a said request message when the  
25 data for the respective subscriber is stored on that home location  
register, and message re-routing means associated with each said  
home location register for forwarding a said subscriber data request  
message to another said further home location register when the data  
for the respective subscriber is not stored on the first home location  
30 register and for providing an indication to said further home location  
register that the request message has been rerouted whereby to limit

the number of diversions to which a said request message is subjected to a predetermined number.

10. A method of retrieving subscriber information in a cellular communications network incorporating a plurality of home location registers on which registers subscriber data is stored such that each subscriber is allocated to a selected one of said registers for voice and/or data calls, the method including generating a message incorporating a request for information relating to a said subscriber, routing the request message to one said home location register, responding from that home location register to the request message when the subscriber data relating to that request is stored on that home location register, diverting the request message from that home location register to a said further home location register when the subscriber data is not found on the selected one home location register, and providing an indication to said further home location register that the request message has been rerouted whereby to limit the number of diversions to which a said request message is subjected to a predetermined number.



The  
Patent  
Office  
18

**Application No:** GB 9803829.2  
**Claims searched:** 1 to 10

**Examiner:** Jared Stokes  
**Date of search:** 24 August 1998

**Patents Act 1977**  
**Search Report under Section 17**

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): H4L (LDSM)

Int Cl (Ed.6): H04Q (7/38)

Other: On-Line - WPI

**Documents considered to be relevant:**

Category	Identity of document and relevant passage	Relevant to claims
A,E	GB 2 314 733 A (N.T.) See whole document	-
A	GB 2 269 962 A (N.T.) See p.9 ln.2-7, p.12 ln.21-26	-

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.